IEC TS 63397

Edition 1.0 2022-12

TECHNICAL SPECIFICATION

colour inside

Photovoltaic (PV) modules – Qualifying guidelines for increased hail resistance

IEC TS 63397:2022-12(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC TS 63397

Edition 1.0 2022-12

TECHNICAL SPECIFICATION

colour inside

Photovoltaic (PV) modules – Qualifying guidelines for increased hail resistance

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-8322-6194-1

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

PHOTOVOLTAIC (PV) MODULES – QUALIFYING GUIDELINES FOR INCREASED HAIL RESISTANCE

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects because each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TS 63397 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
82/2062/DTS	82/2090/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The hail test (MQT 17) of IEC 61215-2:2021, 4.17 examines PV modules for minimum hail resistance by using spherical ice balls of a minimum diameter of 25 mm, or optionally larger. The requirements after the test, as specified in IEC 61215-2, are:

a) no intermittent open-circuit fault detected during the test,

b) no evidence of major visual defects,

c) wet leakage current meeting the same requirements as for the initial measurements and the power loss requirement of (Gate No. 2) IEC 61215-1:2021, 7.2.3.

The hail test (MQT 17) may cause visible damage detectable by MQT 01 as well as invisible internal damage not detectable by MQT 01. Such invisible damage may also only be detected by Gate No. 2 (power loss measurement after stress tests) if the damage is relatively large.

The IEC 61215 series [1][1] lays down requirements for the design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in open-air climates. It is however not written with the intent to detect medium to long term performance losses caused by hail to internal parts not visible to the naked eye. Such internal damages may be micro-cracks of cells which over time can be propagated by other mechanical and thermo-mechanical environmental stresses not addressed by the test flow of IEC 61215-1:2021, Figure 2.

The hail test (MQT 17) of IEC 61215-2:2021, 4.17 is sufficient for the generic design qualification and type approval for applications and environments where PV modules are unlikely to be exposed to severe hail exposure; however, a standardized test for applications and environments where PV modules are likely to be exposed to higher hail stress is considered useful.

IEC 61215-1:2021, Clause A.4 says*:* "Not all modules will experience extreme weather or mishandling. Qualification testing that tests for performance retention under these circumstances may lead to costly overdesign. … It is recommended to first develop and gain experience with a TS related to hail resistance, module handling, and related performance losses. Such a document should consider that thermal cycles might be more effective than DML."

The share of generated photovoltaic energy globally is ever rising and the reliability and more detailed prediction of generated power including energy loss is becoming more important for the industry, in particular to the finance and insurance section of the industry.

The tests given in this document can differentiate the hail resistance of PV modules by exposing samples to hail stress prior to the selected tests of IEC 61215-2:2021, Figure 2 and measure the additional power loss to reference modules going through the same tests without hail stress. The test sequence MQT 20 cyclic (dynamic) mechanical load test, MQT 11 thermal cycling test and MQT 12 humidity freeze test post-hail stress tests used in this document are identical to the test sequence 2 mechanical stress of IEC TS 63209-1:2021 [2]. The hail test HMQT 17 used in this document contains changes to IEC 61215-2:2021, MQT 17 to improve accuracy, comparability and repeatability of results. Additional information can be found in the Hail Register [3]. This document, IEC TS 63397, aims to support in the selection of modules for specific regions with higher risk to hail and the improvement of module design.

In addition to the power loss caused by the additional hail exposure the reporting section includes electroluminescence images. The changes in these images alone are not always indicative of power loss but may, together with the power measurement data, provide additional insight.

[1] Numbers in square brackets refer to the Bibliography.

Recent trends towards larger cell and module sizes may add to the risk of power loss caused by hail. Recent, advanced cell interconnection technologies such as multi-wire technology aim to limit power and energy loss due to cell cracks. On the system site there are trackers to bring modules to their hail stow position to minimize impact.

Not all PV modules will be deployed to regions with increased risk of hail which is why it is not planned to add these requirements to the IEC 61215 series. Annex A gives an example of a global hail map with regions having a higher statistical average of hail exposure and hail ball size.

PHOTOVOLTAIC (PV) MODULES – QUALIFYING GUIDELINES FOR INCREASED HAIL RESISTANCE

1 Scope

This document defines additional testing requirements for modules deployed under applications or in environments where PV modules are likely to be exposed to the impact of hailstones leading to higher stress beyond the scope of the IEC 61215 series.

The current safety standards of the IEC 61730 series [4] and design qualification and type approval standards of the IEC 61215 series specify tests for the ability of PV modules to withstand a defined hail impact. The requirements therein are the minimum for market entrance and are not written to propagate potential cell damage caused by the hail impact by subsequent mechanical and thermo-mechanical tests simulating the environmental stress that modules will potentially be exposed to after hailstorms. In this document modules are initially exposed to 200 h of damp heat to account for some level of humidity and heat before the first hail exposure. After that they are exposed to hail stresses and then to the selected thermo-mechanical stress tests of sequence C of IEC 61215-1:2021, Figure 2. The power loss from these modules is then compared to reference modules that have been through the same stress tests except the hail stress.

Comparison of electroluminescence images and performance of both reference modules and modules exposed to hail stress provides additional insight regarding hail resistance and susceptibility.

This document aims to assist in the selection of modules for deployment in specific regions that have a higher risk of hail damage and to provide tools for improving module design.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 60904-13:2018, *Photovoltaic devices – Part 13: Electroluminescence of photovoltaic modules*

IEC 61215-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

IEC 61215-1-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules*

IEC 61215-2:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61730-1, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61215-1, IEC 61730-1, and IEC TS 61836 and the following apply:

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
MQT
module quality test
specific quality test carried out on a photovoltaic module in accordance with IEC 61215-1:2021

3.2
HMQT
hail module quality test
revised hail test MQT 17 of IEC 61215-2:2021 followed by mechanical and thermo-mechanical chamber stress tests

4 Number and selection of test samples

The sample selection, number of samples, and sample sets are left to the user based on the purpose of the data collection. For each ice-ball diameter to be tested, module type (individual bill of material (BOM), see also IEC TS 62915 [5]) and mounting configuration in this document, at least two samples shall be tested. Test results for modules made of different materials, modules with different designs and modules used in different mounting configurations are expected to be different. In addition, for each model tested, one reference sample not exposed to hail stress is required per ice-ball diameter to measure the power loss. To increase confidence in the test results a larger number of test samples, and inclusion of multiple samples is encouraged.

5 Test procedures

5.1 General

Subclauses 5.2 to 5.15 provide detailed instructions for performing each module quality test (MQT). A complete test flow can be found in Figure 3.

5.2 Visual inspection (MQT 01)

Observations are completed as defined in IEC 61215-2:2021, MQT 01. All observations shall be recorded and reported as part of the final report. Photographs shall be used to document any changes and included in the final report.

5.3 Initial stabilization (MQT 19.1)

Initial stabilization shall be completed as defined in IEC 61215-2:2021, MQT 19.1. All measurements (as defined in 5.4) shall be recorded after each stabilization step. These data shall be included in the final report.

5.4 Performance at STC (MQT 06.1)

The performance at standard test conditions (STC) shall be measured as defined in IEC 61215-2:2021, MQT 06.1. All measurements shall be included in the final report.

5.5 Performance at low irradiance (MQT 07)

The performance at low irradiance shall be measured as defined in IEC 61215-2:2021, MQT 07. All measurements shall be included in the final report.

5.6 Insulation test (MQT 03)

The insulation shall be tested as defined in IEC 61215-2:2021, MQT 03. The insulation resistance measurement shall be recorded and reported as part of the final report.

5.7 Wet leakage current test (MQT 15)

The wet leakage current shall be measured as defined in IEC 61215-2:2021, MQT 15. The measured leakage current shall be recorded and reported in the final report.

5.8 Electroluminescence imaging

Electroluminescent imaging for both the reference and HMQT sample shall be completed as defined in IEC TS 60904-13, using both low and high injection levels for the initial characterization. This test is for informative purposes only. No pass/fail criteria apply. For a schematic example see Table 3.

5.9 Damp heat test (MQT 13)

This test is equivalent to IEC 61215-2:2021, MQT 13, but for a duration of 200 h only. The measured leakage current shall be recorded and reported in the final report.

5.10 Hail test (HMQT 17)

5.10.1 General

This test is based on IEC 61215-2:2021, MQT 17 and the Hail Register. For the purposes of this document the ice-ball diameter shall be selected from Table 1.

Models may be tested for one or more ice-ball diameters. However, to evaluate ice-ball diameter specific changes in power loss and module damage it is encouraged to test for a number of different ice-ball diameters, starting with a small diameter.

Ice balls vary in mass within one ice-ball diameter. For comparability and repeatability of results it is important to stay within the kinetic energy range as described in Table 1. To account for the different masses of ice balls the velocity shall therefore be adjusted to stay within the kinetic energy range.

5.10.2 Purpose

To verify that the module is capable of withstanding the impact of hail.

5.10.3 Apparatus

a) Moulds of suitable material for casting spherical ice balls of the required diameter. For each ice-ball diameter to be tested, at least two modules shall be tested. The test report should indicate what ice-ball diameter, mass, test velocity and resulting kinetic energy were used for the hail test.

b) A storage freezer controlled at (−20 ± 3) °C.

c) A launcher capable of propelling an ice ball with adjustable velocity to reach the kinetic energy range, so as to hit the module within the specified impact location. The path of the ice ball from the launcher to the module may be horizontal, vertical or at any intermediate angle, so long as the test requirements are met.

d) A rigid mount for supporting the test module by the method specified by the manufacturer, with the impact surface normal to the path of the projected ice ball.

e) A balance for determining the mass of an ice ball to an accuracy of ±2 %.

f) An instrument for measuring the velocity of the ice ball to an accuracy of ±2 %. The velocity sensor shall be no more than 1 m and no less than 0,3 m from the surface of the test module.

As an example, Figure 1 shows in schematic form a suitable apparatus comprising a horizontal pneumatic launcher, a vertical module mount and a velocity meter which measures electronically the time it takes the ice ball to traverse the distance between two light beams. This is only one example as other types of apparatus including slingshots and spring-driven testers have been successfully utilized.

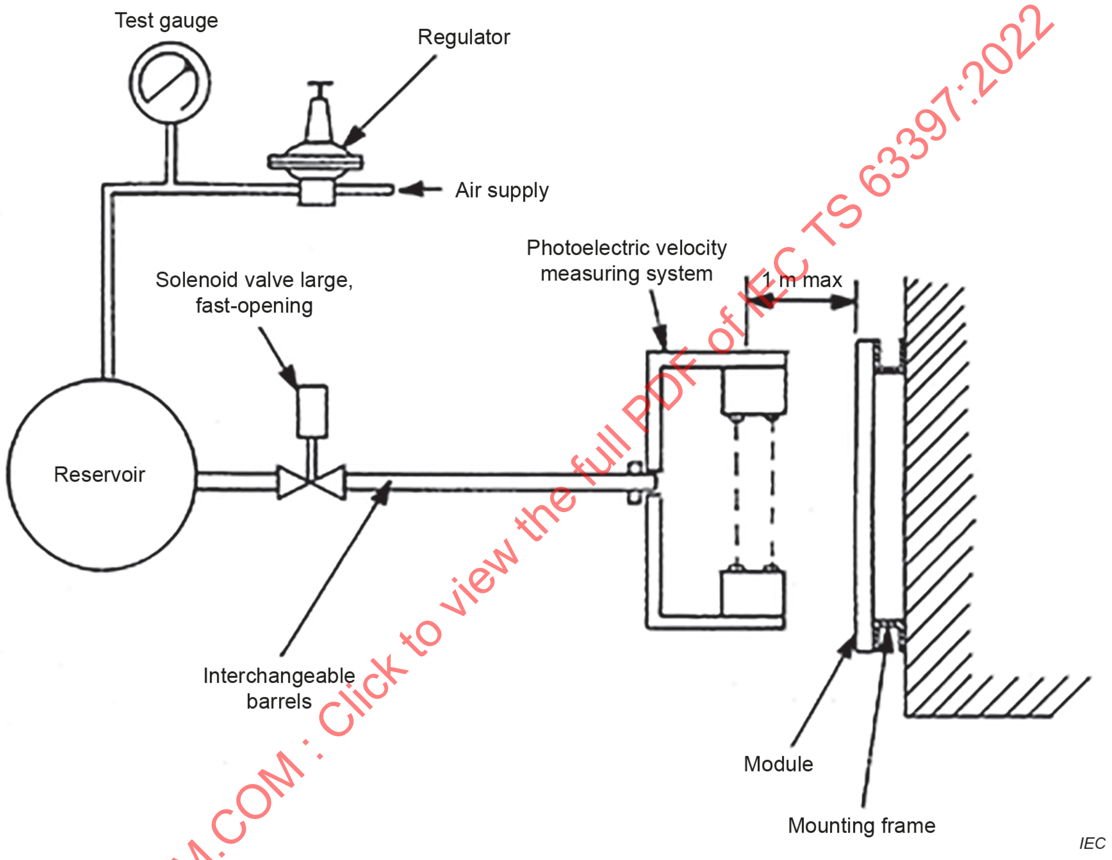


Figure 1 – Hail test equipment

Table 1 – Ice-ball masses and kinetic energy

Nominal diameter	Minimum mass[a]	Maximum mass[b]	Guidance velocity[c]	Minimum kinetic energy[d]	Maximum kinetic energy[e]
mm	g	g	m/s	J	J
25	6,8	7,9	21,8	≥ 1,7	≤ 2,3
30	11,7	13,6	23,9	≥ 3,5	≤ 4,4
35	18,6	21,6	25,8	≥ 6,5	≤ 7,9
40	27,7	32,3	27,5	≥ 11,1	≤ 13,2
45	39,5	46, 0	29,2	≥ 17,7	≤ 20,9
50	54,1	63,1	30,8	≥ 27,0	≤ 31,5
55	72,0	84,1	32,3	≥ 39,5	≤ 45,9
60	93,5	109,1	33,7	≥ 56,0	≤ 64,7
65	118,9	138,8	35,1	≥ 77,1	≤ 89,0
70	148,5	173,3	36,4	≥ 104	≤ 120
75	182,6	213,2	37,7	≥ 137	≤ 157
80	221,6	258,8	39,0	≥ 177	≤ 204

The values given in this Table 1 are based on IEC 61215-2:2021, Table 2 and the Hail Register.

[a] Lowest possible mass of ice ball. Mass based on density of 870 kg/m^3.

[b] Highest possible mass of ice ball. Mass based on ideal density of 920 kg/m^3.

[c] Guidance velocity to be adjusted based on actual measured ice-ball mass to generate kinetic energy within acceptable range of minimum and maximum kinetic energy.

[d] Minimum kinetic energy for an ice-ball shot to be valid.

[e] Maximum kinetic energy for an ice-ball shot for a valid failed result. Passed results with a higher kinetic energy may (in agreement with the module manufacturer) also be counted as valid. Failed results with a higher kinetic energy are not valid, tests shall be repeated.

EXAMPLE 1 An ice ball with a nominal diameter of 25 mm has a relatively low mass of 6,8 g. A kinetic energy within the required range of between 1,7 J and 2,3 J can be achieved with a velocity of between 22,4 m/s and 26 m/s. An ice ball with a nominal diameter of 25 mm has a relatively high mass of 7,9 g. A kinetic energy within the required range of between 1,7 J and 2,3 J can be achieved with a velocity of between 20,8 m/s and 24,1 m/s.

EXAMPLE 2 An ice ball with a nominal diameter of 45 mm has a relatively low mass of 39,5 g. A kinetic energy within the required range of between 17,7 J and 20,9 J can be achieved with a velocity of between 29,9 m/s and 32,5 m/s. An ice ball with a nominal diameter of 45 mm has a relatively high mass of 46 g. A kinetic energy within the required range of between 17,7 J and 20,9 J can be achieved with a velocity of between 27,7 m/s and 30,1 m/s.

5.10.4 Procedure

a) Using the moulds and the freezer, make a sufficient number of ice balls of the required size for the test, including some for the preliminary adjustment of the launcher.

b) An acceptable ball shall meet the following criteria:
   - no cracks visible to the unaided eye;
   - diameter within ±5 % of that required;
   - mass within minimum and maximum range as listed in Table 1.

c) Ensure that all surfaces of the launcher likely to be in contact with the ice balls are near room temperature.

d) Fire a number of trial shots at a simulated target in accordance with step f). Adjust the launcher until the velocity of the ice ball, as measured with the velocity sensor in the specified position, is within the to be adjusted velocity to achieve the required kinetic energy as in Table 1.

   Passed results with a higher than the maximum kinetic energy of Table 1 may (in agreement with the module manufacturer) be counted as valid too and reported. Failed results with a higher kinetic energy are not valid, tests shall be repeated. For shots to be repeated an equivalent location on the module shall be used. Shots shall not be fired at the same spot.

e) Mount the module according to the manufacturer's specifications. The module shall be at room temperature, with the impact surface normal to the path of the ice ball. For flexible modules, the modules shall be mounted per the manufacturer's documentation with specified substrate and adhesive or attachment or mounting means during the test. If the manufacturer's specified application allows mounting in a rigid or flexible mounting condition, testing shall be done on the worst-case condition(s). More than one worst-case condition may exist. The test configuration(s) shall be documented in the test report.

f) Take an ice ball from the storage freezer and place it in the launcher. Take aim at the first impact location specified in Table 2 and fire. The time between the removal of the ice ball from the freezer and impact on the module shall not exceed 60 s.

g) Inspect the module in the impact area for signs of damage and make a note of any visual effects of the shot. Errors of up to 10 mm from the specified location are acceptable.

h) If the module is undamaged, repeat steps f) and g) for all the other impact locations in Table 2 , as illustrated in Figure 2.

Table 2 – Impact locations

Shot No.	Location
1	Any corner of the module window, not more than one radius of ice ball from the module edge.
2	Any edge of the module, not more than one radius of ice ball from the module edge.
3, 4	Over the circuit near interconnects (i.e. cell interconnects and bus ribbons).
5, 6	Over edges of the circuit (e.g. individual cells).
7, 8	On the module window, not more than one radius of ice ball from one of the points at which the module is mounted to the supporting structure.
9, 10	On the module window, at points farthest from the points selected above.
11+	Any points which may prove especially vulnerable to hail impact like over the junction box.

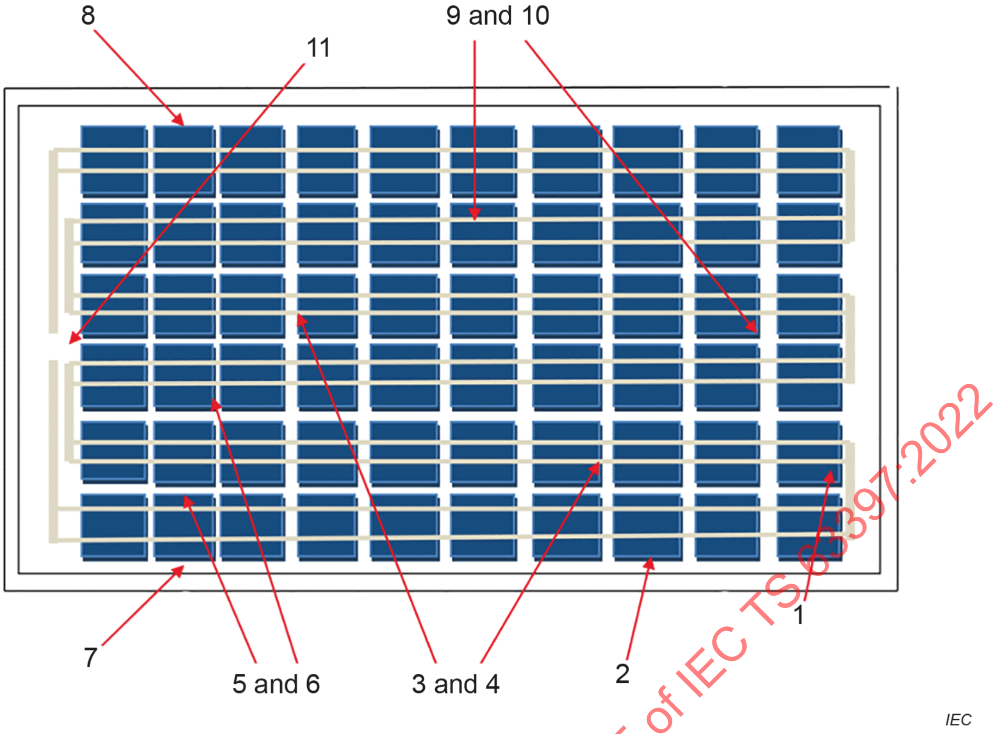
5.10.5 Final measurement

Repeat tests MQT 01 (5.2) and MQT 15 (5.7).

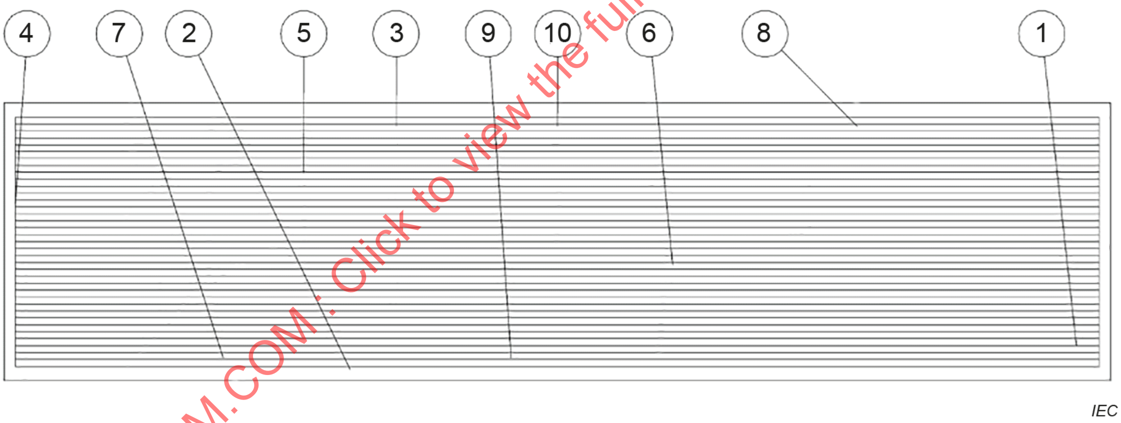
5.10.6 Requirements

a) No evidence of major visual defects, as defined in IEC 61215-1.

b) Wet leakage current shall meet the same requirements as for the initial measurements.



a) Impact locations for wafer/cell based technologies



b) Impact locations for monolithic thin film technologies

Figure 2 – Hail test example impact locations for wafer/cell based technologies and for monolithic thin film technologies

5.11 Cyclic (dynamic) mechanical load test (MQT 20)

The cyclic (dynamic) mechanical load test shall be performed according to IEC 61215-2:2021, MQT 20.

5.12 Thermal cycling test (MQT 11)

The thermal cycling shall be performed according to IEC 61215-2:2021, MQT 11. The number of cycles shall be 50. For bifacial modules, the current applied during MQT 11 shall be that defined in IEC 61215-1-1: the peak power current at bifacial stress irradiance (BSI).

5.13 H

5.14 umidity-freeze test (MQT 12)

The humidity-freeze test shall be performed according to IEC 61215-2:2021, MQT 12.

5.15 Final stabilization test (MQT 19.2)

Final stabilization shall be applied according to IEC 61215-1:2021, MQT 19.2 and the technology specific parts of the IEC 61215 series. In 5.8 of this document, each final stabilization shall include the stress-specific stabilization for BO-LID, as specified in IEC 61215-2:2021, MQT 19.3.

5.16 Requirements

a) The power loss shall be reported only.

b) For the insulation test requirements of IEC 61215-2:2021, MQT 03 applies.

c) For the wet leakage current test requirements of IEC 61215-2:2021, MQT 15 applies.

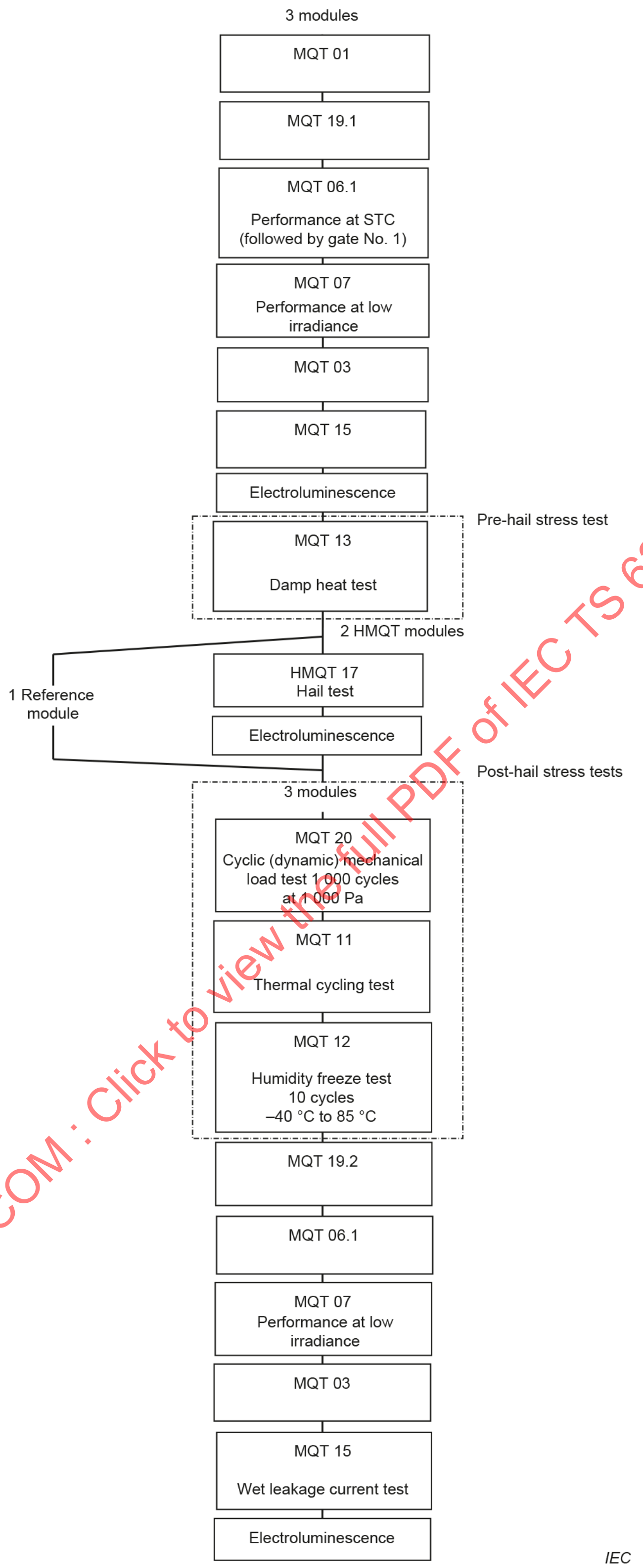


Figure 3 – Test flow

6 Report

The reporting requirements of IEC 61215-1 shall be followed in their entirety for applicable tests in this document. In addition the following information shall be added:

– Table as shown in Table 3 indicating what hail ball diameters have been used with resulting power loss to P_{max} (NP) and P_{max} (Lab) compared to a reference module.

– Table as shown in Table 4 displaying electroluminescence images for both reference and hail-stress modules prior and post stress. Damages as characterized according to IEC TS 60904-13 shall be reported.

Table 3 – Example of power loss reporting

Type: XYZ		**P_{max} (NP) [W]: 300**					
Hail ball Ø and E_k		**P_{max} (Lab) Reference module**	**P_{max} (Lab) HMQT module**	**Post stress* Reference module**		**Post stress* HMQT module**	
mm	J	W	W	W	% to P_{max} (Lab)	W	% to P_{max} (Lab)
35	21,5	299	299	295	−1,3	290	−3,0
35	21,3	299	298	295	−1,3	291	−2,3
40	32,0	299	299	295	−1,3	280	−6,4
40	32,1	299	300	295	−1,3	278	−7,3
45	45,8	299	299	295	−1,3	265	−11,4
45	45,9	299	301	295	−1,3	261	−13,3
50	63,0	299	299	295	−1,3	D	D
55	NT	NT	NT	NT	NT	NT	NT

Key

D damaged, not in compliance with MQT 03 Insulation test or MQT 15 Wet leakage current test

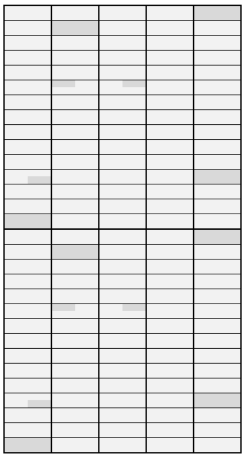
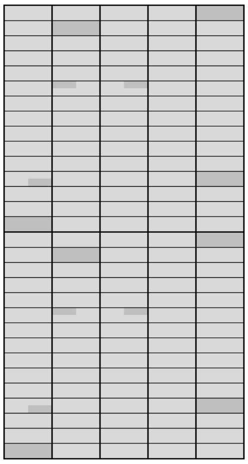
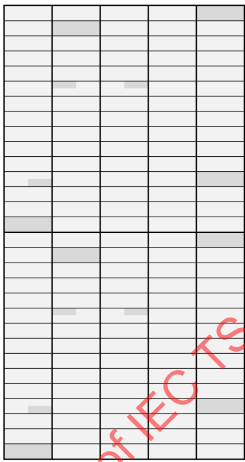
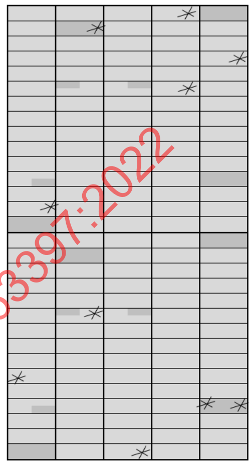
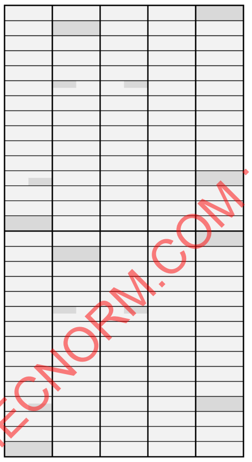
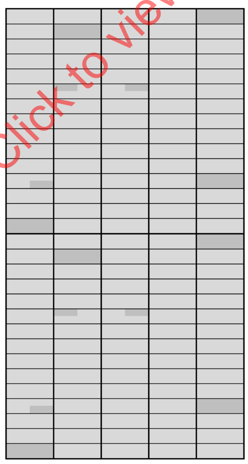
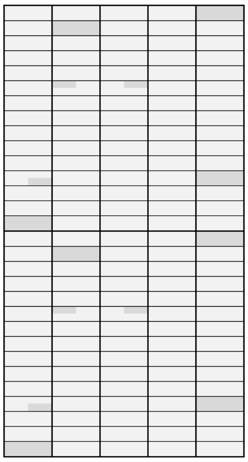
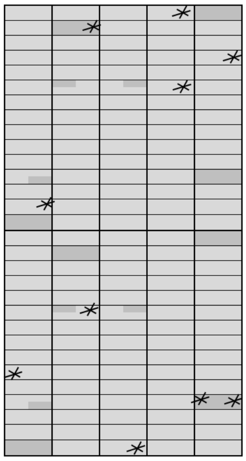
NT not tested

* end of test sequence

The light grey shaded cells relate to reference modules going through all tests, except the hail impact test.

The dark grey shaded cells relate to HMQT modules going through all tests, including the hail impact test.

Table 4 – Schematic example of electroluminescence images prior and post stress tests

Electroluminescence images				
	Reference module		Hail stress module	
Hail ball size Ø mm	**Prior to stress**	**Post stress**	**Prior to stress**	**Post stress**
40				
				Damage characterization[a] Annex D: Cell cracking Annex C: Mode B cracks, partially disconnected cell regions
45				
				Damage characterization[a] Annex D: Cell cracking Annex C: Mode C cracks, essentially electrically disconnected regions

[a] Visible damage characterization as defined in IEC TS 60904-13:2018, Annex C (quantitative) and Annex D (qualitative).